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DESIGN AND REFINEMENT OF AN AUTOMATED METHOD OF DOCUMENTING COMBAT CASUALTY CARE

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NAVAL MEDICAL RESEARCH AND DEVELOPMENT COMMAND
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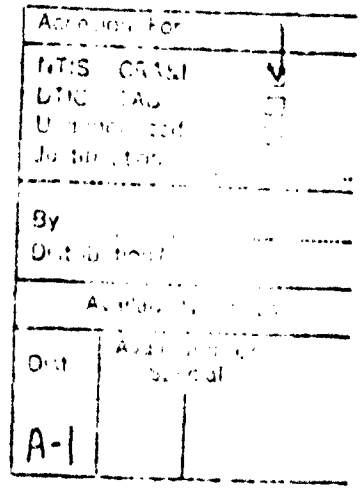

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SUMMARY

Problem

The systematic documentation of combat casualty medical information is critical to ensuring continuity of care. However, the current instrument for documenting battlefield medical data, DD Form 1380, Field Medical Card (FMC), has been found to be deficient.

Objective

The present study seeks to evaluate the feasibility of capturing battlefield medical data with an electronic tag to be worn by combat personnel. This tag would require no external equipment to read or write information.

Approach

A prototype electronic medical data tag, named MEDTAG, and a nonfunctional ergonomic mock-up of the device were fabricated. Open ended interviews were used to obtain data on user reaction to the prototype's data capture capability and to obtain feedback on means for improving its physical design and functionality. Survey questionnaires provided data concerning ergonomic considerations.

Results

High positive ratings were obtained regarding MEDTAG's ability to gather data faster and more accurately than current manual methods. In addition, both the documentation of self-aid and buddy-aid were supported and the backlighted screen greatly improved data gathering during nighttime operations. Ergonomic evaluations revealed a user preference for a smaller device. Screen size and the placement of the data input buttons were rated unacceptable.

Conclusions

Evaluation of the MEDTAG proof-of-concept model has demonstrated the potential for enhancing the efficiency and the quality of medical data collection at the forward treatment echelons through the application of automation. Because of MEDTAG's menu-driven method of data input, the previously encountered impediments to reading and writing information to electronic battlefield data carriers have been effectively overcome. However, data capture capability could be improved by enhancing the device's ability to capture a wider range of battlefield medical information.

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INTRODUCTION

Following the administration of battlefield medical procedures, Navy corpsmen are instructed to document the medical status of each casualty encountered and attach the record to the patient. As the patient is moved through the medical chain of evacuation, the systematic documentation of medical information is critical in ensuring continuity of care (Gunderson et al, 1984). However, the pressure to quickly diagnose, treat, and evacuate casualties often forces documentation into a low priority status.

The instrument for documenting battlefield injury and treatment information for the last 40 years has been the Field Medical Card (FMC), DD Form 1380 (FMFM 4-5, 1982). Unless a substantial amount of time is devoted to Field Medical Card documentation, accuracy and completeness is often unacceptable (Wilcox, Galarneau, & Fitzgerald, 1993). For example, when documentation is done too quickly, patient identification is often limited to a last name or the last four digits of the social security number, and treatments administered along with date and time of the injury are often missing or incorrect.

Because the Field Medical Card has historically failed to provide quality information, the Medical Readiness Strategic Plan (MRSP, 1988) declared that the FMC was deficient and, as a result, a quad-service working group was formed to review the instrument. Substantial effort was expended by this working group to make the card easier to read and complete (Wilcox, 1990).

Evaluation of the revised card by Naval Health Research Center (NHRC) concluded that, while it was seen as an improvement over the old form, many longstanding problems persist (Wilcox, 1990). For example, a pen or writing instrument is still required for documentation, and corpsmen or medics must still carry the booklets which take valuable space. In addition, because only medical personnel possess the booklets, self-aid or buddy-aid cannot be documented. Acceptable documentation using the Field Medical Card takes more than three minutes which, according to experienced Navy Fleet Marine Force (FMF) corpsmen, is too much time to relinquish during combat (Wilcox, Galarneau, & Fitzgerald, 1993).

With the development of microprocessors, the military began exploring the potential of applying such technology on the battlefield. In the early 1980s the Army proposed the "Paperless Battlefield" where medical and administrative data could be electronically acquired (Smith, 1989). The development of the Theater Army Medical Management Information System (TAMMIS) allowed for the partial fulfillment of this goal. Currently, TAMMIS operates at, or behind, the third treatment echelon.

Efforts to develop a division level version of TAMMIS (TAMMIS-D) for use at Battalion Aid Stations and second echelon medical facilities proved to be less rewarding (Smith, 1989). In this effort, an "Individual Carried Record" (ICR) was envisioned as the method for implementing medical record-keeping requirements at these facilities. During feasibility tests, Electronically Erasable Programmable Read Only Memory (EEPROM) chips were used as the data storage medium. These chips were encased in hardened plastic with contacts left exposed to accommodate hardware interfaces. Entering or extracting data from the tag, however, required that medical aid personnel carry specialized reader/writer devices into combat. Without a reader/writer, the EEPROM tag was unusable. Because of this and other problems related to data storage, the full potential of the Army's TAMMIS-D project was never realized. The ICR concept is currently undergoing reconsideration under the Army's Automated Soldier Information System (ASIS) (Romano, 1992).

In efforts parallel to those of the Army, the Navy also examined plastic-coated EEPROM chips during the 1980s and found them rugged and reliable but, because the tags were not human-readable, they were found to be useless if the reader device was lost or malfunctioned (Wilcox, 1987). Furthermore, Navy corpsmen indicated that they had no desire to carry extra equipment, such as reader/writers, around with them during combat missions.

The Air Force has directed most of its ICR development effort toward solutions based upon bar-coding, magnetic-stripe, and "smart-card" technologies (Dobbs et al. 1990). In such systems a reader/writer device, generally attached to a small computer, is used to enter or extract patient medical data. While a workable solution in the relative stability of aeromedical facilities, the problems related to carrying reader/writer devices into combat remain unresolved.

Although automation of personal identification and medical information in the battlefield has been demonstrated, a viable means of recording specific treatment information under combat conditions remains to be developed. These problems were investigated by fabricating a functional prototype electronic medical data tag and a nonfunctional ergonomic model (Fortney, 1991). The functional prototype implemented the methodology for capturing data without

external read/write hardware; however, this unit was larger than the target operational unit so the potential for evaluation of the user interface was limited. To investigate issues regarding the user interface and the physical size of the target operational unit, the ergonomic model was used.

Functional Prototype Device

The prototype device, named MEDTAG (see Figure 1), is an extension of the Navy's earlier EEPROM tag research (Wilcox, 1987). There are two primary enhancements to these earlier efforts. First, an integrated read/write capability has been added to the tag. Second, the device has been supplemented with an internal clock to provide accurate date and time tracking. Included in this first stage prototype are a backlighted LCD screen used to present the user with menu options, two mechanical data input buttons for identifying and recording selections, an activation switch, a data communications port for transferring information to and from a host computer, and core electronics.

The core electronics include Electronic Programmable Read Only Memory (EPROM) used to store the operational software, Electronic Erasable Programmable Read Only Memory (EEPROM) for storing medical data, and a microcontroller to execute the operational software. A power pack housing two 3-Volt D-cell lithium batteries provides power to operate both the electronic circuitry and to illuminate the backlighted display. The power pack, due to physical size constraints, is located externally.

Personal ID information, along with current date and time, are preloaded into MEDTAG from a PC via the device's communications port. Specific ID information items stored in the device are identical to those requested by the redesigned FMC and include name, rank, social security number, sex, nation, force, unit, specialty, and religion. Data capture, storage, and retrieval is controlled by software which allows the user to store and retrieve data by traversing a set of menus. A two-button mode of operation permits the user to navigate the menu structure and to enter data rapidly by moving directly to the desired data category or function. Upon activation, MEDTAG is placed in a data capture/retrieval mode of operation and the main menu options are displayed (see Figure 1). The data elements comprising the menus are designed to provide the user with an information-collecting capability that is comparable to the FMC. Therefore, the device provides the ability to both document and retrieve general patient information related to injury assessment, treatments administered, patient condition, and patient disposition. In addition, the device provides options for reassessing patient condition and reviewing previously recorded information. The list of the MEDTAG menus and each of their data elements is shown in

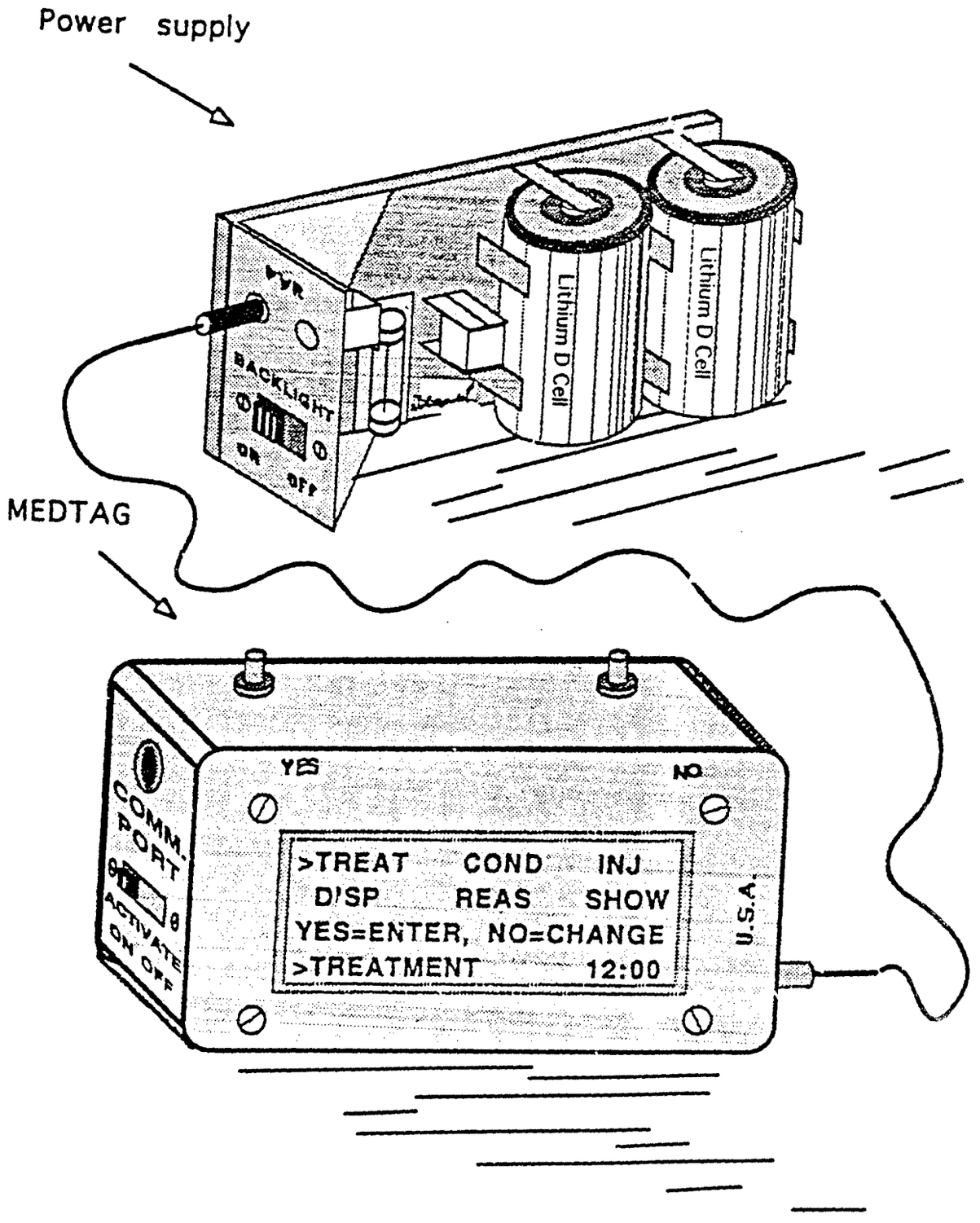

Figure 1. Artist rendering of the MEDTAG prototype and power supply.

Appendix A. All recorded patient identification and field treatment history can be transferred to a PC for printed or electronic storage.

Nonfunctional Ergonomic Mock-up

The MEDTAG prototype served solely as a proof-of-concept model and was not designed to reflect the physical size or appearance envisioned for the final product. To begin evaluation of issues which would be associated with a miniaturized production version, a nonfunctional, ergonomic mock-up of MEDTAG was also fabricated (Fortney, 1991) (see Figure 2). Development of the ergonomic mock-up was initiated with the identification of features critical to optimizing the use and performance of the device under combat conditions. Artist renderings of various ergonomic concepts were generated and evaluated in terms of the degree each one effectively incorporated the required operational features. The results of this evaluation were used to develop a final ergonomic mock-up which had features to facilitate data entry and readability, had dimensions sufficient for both comfortable hand held operation and user wearability, and used a simple method of operation. In the present paper, both the functional prototype and the nonfunctional mock-up were evaluated to assess the technical feasibility of the MEDTAG concept.

METHOD

Sample

Medical-care providers, stationed at six Navy medical commands in the Southern California area participated in the study. These included field medical training staff, independent duty corpsmen, emergency-room staff, Navy ambulance personnel, and laboratory technicians. Participants at each site were shown the ergonomic mock-up, given a technical description of the concept, and a demonstration covering operation of the prototype device.

Procedures and Instrumentation

Interviews. Open-ended discussions were used to evaluate user reaction to the device's data capture capability and to obtain feedback on means for improving its physical configuration and capabilities. Recommendations for modifications and refinements for improving device effectiveness were noted and recorded.

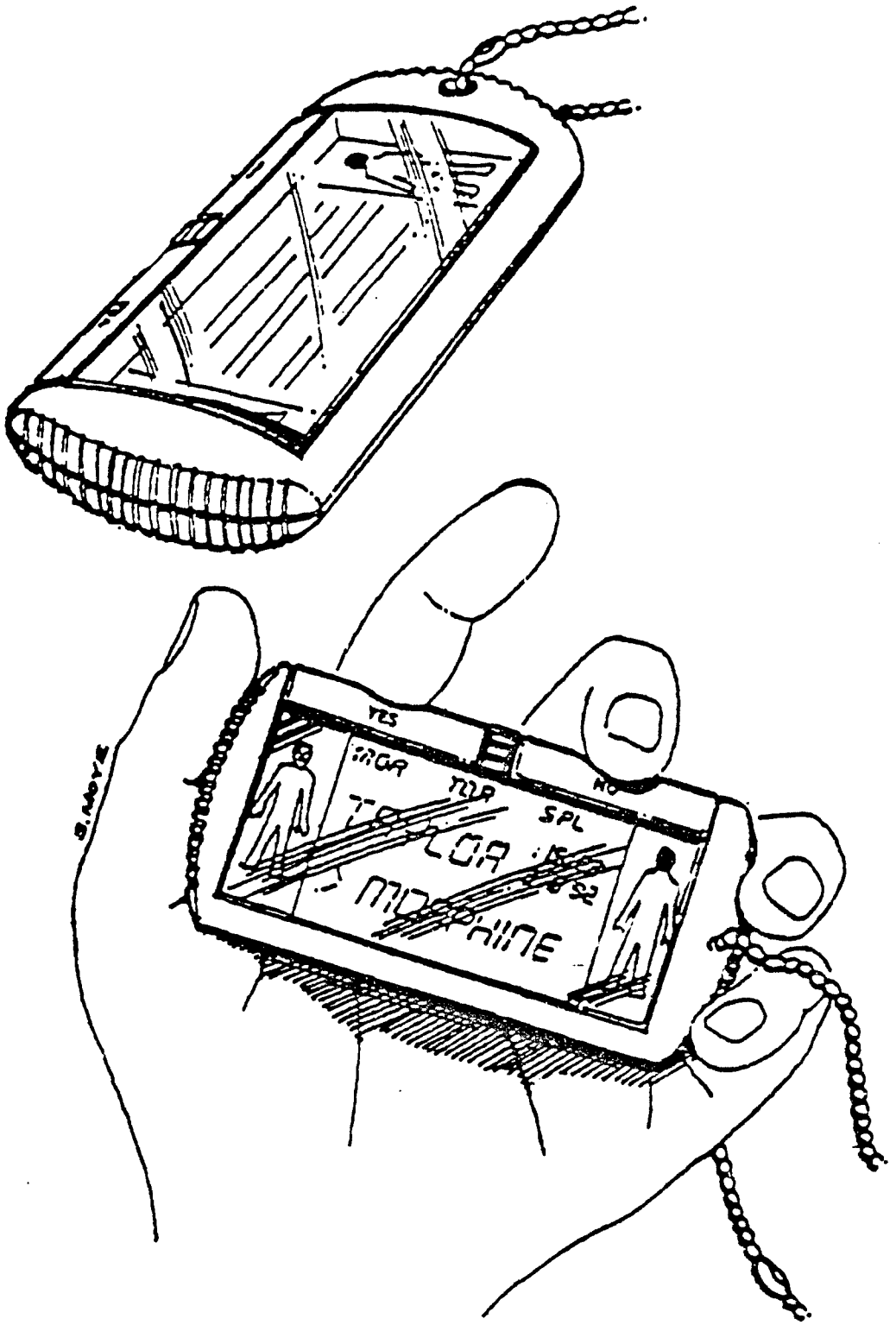

Figure 2. Artist rendering of MEDTAG ergonomic model.

Survey. Following the demonstration, participants were asked to respond to a questionnaire (Appendix B) concerning the size, shape, and capabilities of the device. A total of 100 questionnaires were obtained.

RESULTS AND DISCUSSION

Interview and Observation Results

Table 1 presents the results obtained from the interviews and open-ended discussions. It was observed that the majority of users quickly grasped the data entry concept and readily adapted to the device. Users exhibited little difficulty traversing the menu structures, quickly locating appropriate items. It was determined, however, that the device was not fully capable of capturing the most critical and common battlefield information. This was due to the fact that the device's software was designed to precisely emulate the data collection format of the FMC. Emulation of the FMC's data entry format failed to take into consideration the Card's ability to accept a wide range of textual information. To automate such a capability requires expanding the range of available data elements in each data input menu. For example, the "TREATMENTS" menu should allow for the documentation of assisted ventilation, chest tube insertions, specific IV solutions, dressings applied, and treatment for shock.

Information is recorded with the MEDTAG when the user advances the pointer using the "NO" button, and then presses the "YES" button to select the desired item. The device then automatically records the item selected and the time and date the selection was made. Those providing feedback frequently reported that they were often unsure if the item was actually recorded because the pointer remained positioned at the same location with no apparent action having taken place. Presenting a screen displaying immediate user verification (i.e., "YOU ARE SELECTING...") was suggested as a means of confirming that items were actually recorded.

Mixed results were obtained in the evaluation of the "SHOW-DATA" menu option. Data recall for both personal ID and patient treatment information, while consistently accurate and precise, required excessive user interaction to obtain. To review previously recorded information, the user had to push a button to bring forward each new line of data. This manual approach to scrolling the data across the screen was found to be laborious and time-consuming. Consequently, it was suggested that an automatic screen scrolling feature be incorporated.

TABLE 1

MEDTAG INTERVIEW AND DISCUSSION FINDINGS

- The two-button data entry methodology facilitated rapid data input.
- The number of data elements in each of the "MAIN MENU" categories should be expanded to include a wider range of items.
- Prompts should be added which inform users when a selected item is permanently recorded.
- The "SHOW DATA" function for reviewing previously recorded data should use a screen scrolling feature which automatically displays one line of data at a time.
- The "END" menu option should be replaced with another term which more clearly communicates its function, such as "EXIT."
- The multimenu, multilevel data entry methodology was easily learned.
- The on/off toggle switch used to activate the prototype should be replaced by a mechanism which more closely demonstrates the irreversibility of the activation function.
- Display backlighting intensity should be adjustable.
- Protective covers or seals should be used to reduce the potential for environmental exposure of internal electronic components.

Users reported some confusion regarding the menu option "END," which appeared as the last item in each data collection menu. This option was provided as the means by which the user could exit a menu after an item had been recorded or return to a previous menu had the current menu been entered unintentionally. Many users, however, indicated that they thought the "END" option would terminate data collection before they were finished. Others reported that they interpreted it to mean the end of the menu list. To clarify the purpose of this function it was suggested that the term "END" be replaced with the term "EXIT" in each of the menus.

The standard on/off toggle switch used as the prototype's activation mechanism proved effective in turning the device on, clearing the memory for the next user and turning the device off again. This action, however, was unrealistic because it did not fully illustrate the intended irreversible nature of the device once transitioned to the active/data collection mode of operation.

During informal nighttime evaluations of the device conducted during Camp Pendleton Field Medical Services School training exercises, it was observed that the display backlighting was too bright. It was reported that a high light intensity level could lead to the compromise of position location by enemy troops. It was further noted during these exercises that the MEDTAG's communications port was too susceptible to environmental contaminants such as dirt, dust, and mud, due to its exposed and unprotected position on the bottom of the device.

Survey Results

Figure 3 presents the questionnaire results regarding respondents' attitudes toward the utility of the MEDTAG device as a field data collection instrument. A 10-point scale was used which ranged from a low of 1, indicating a very unfavorable attitude toward the concept, through a high of 10, indicating a very favorable attitude toward the concept. The mean rating on this scale was 8.0.

Table 2 presents the results obtained for the remaining questionnaire items. High positive ratings were obtained regarding the device's ability to gather data faster and more accurately than current methods. Indication that the device could operate effectively at night and provide for documentation of buddy-aid and self-aid was also obtained. Regarding nighttime operations, 92 of the 97 responding indicated that the backlighted screen would make the device useful at night. To measure the MEDTAG's ability to provide for documentation of buddy-aid and self-aid, respondents were asked to indicate whether they thought training would be necessary to

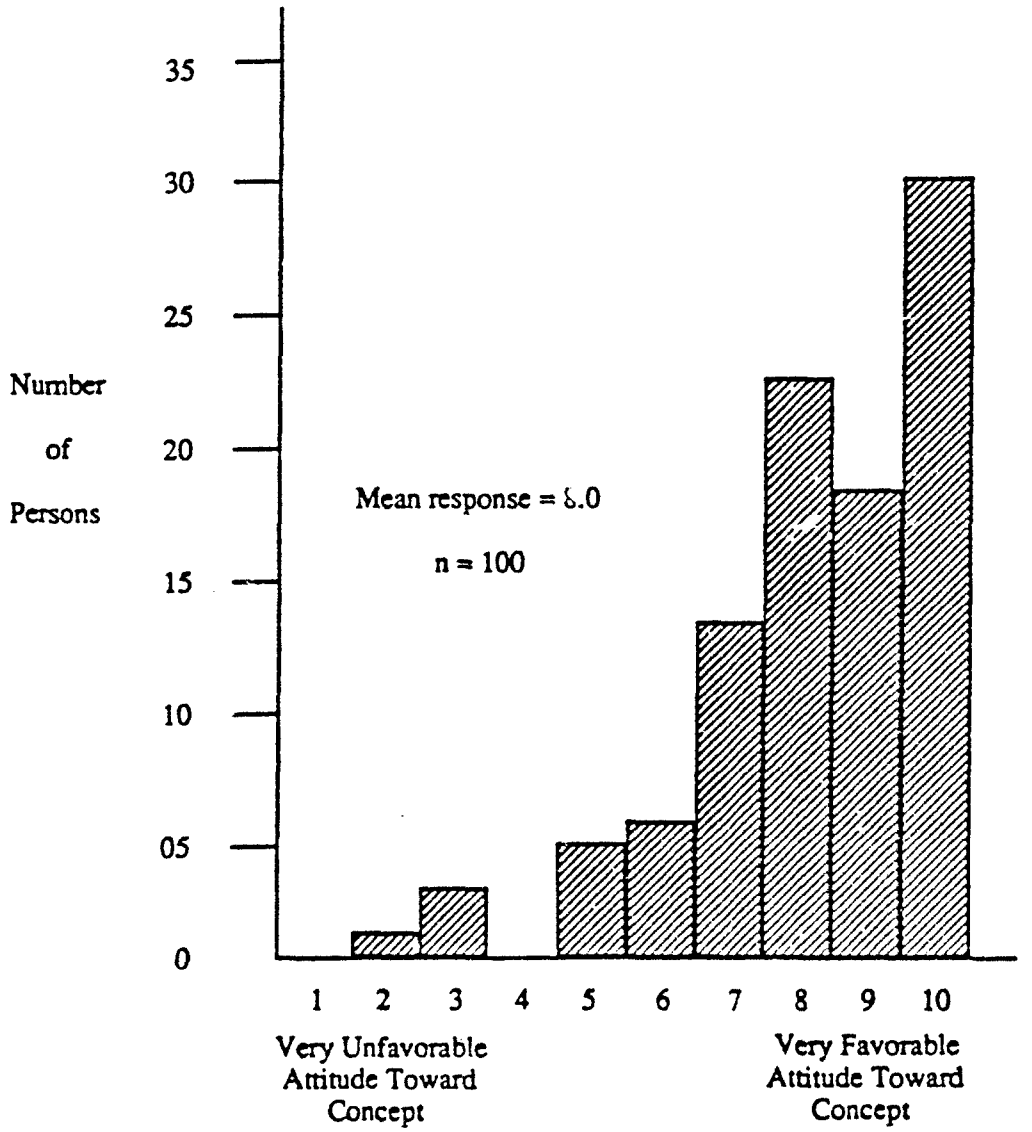

Figure 3. Respondents' attitudes toward the value of the MEDTAG device as a field data collection instrument.

effectively use the device. Of those responding, well over one half indicated that they felt formal training would not be a required prerequisite.

Table 2

QUESTIONNAIRE RESPONSES ON MEDTAG EVALUATION

	% RESPONSE FREQUENCY		
QUESTIONNAIRE ITEM	YES	NO	NO RESPONSE
1. Would documentation procedure be faster using the device?	88	07	05
2. Would device get in the way?	20	75	05
3. Would documentation be more accurate using the device?	83	07	10
4. Would the device be used?	47	44	09
5. Are the data input buttons comfortably positioned?	85	09	06
6. Could the device be effectively used by untrained personnel?	59	37	04
7. Should the size of the screen be reduced?	38	58	04
8. Could the device be effectively used at night?	92	05	03
9. Should the size of the device be reduced?	52	42	06

n=100

Respondents were also asked to evaluate the size and physical layout of the device using the ergonomic mock-up as the standard of comparison. The results concerning size of the device were split, with little more than one half indicating that it should be smaller. Regarding the size of the screen, 38 of the 96 responding indicated that it should be smaller.

When asked about the placement of the two data input buttons, 85 of the 94 responding reported that the buttons were comfortably positioned. It was noted upon observation of the subjects handling the prototype, however, that the placement of the two data input buttons along the side in a vertical orientation encouraged users to hold and operate the device with both hands. Ideally, the device should be operable with a single hand, so that medically related procedures, such as maintaining pressure on a bleeding wound, can be performed while data is being entered into the device.

CONCLUSIONS

To determine the feasibility of automating the collection of combat casualty data, the MEDTAG concept was proposed and a functional proof-of-concept model evaluated. This attempt at automating the medical record has demonstrated its potential for increasing the efficiency and the quality of data collection at the lower treatment echelons while reducing the administrative burden on medical personnel. As this burden is reduced, personnel resources become available which may then be redirected toward accomplishing the primary mission of casualty care.

The pattern of results obtained clearly demonstrated the feasibility of the MEDTAG concept. Because of the MEDTAG's self-contained data capture capability, the concerns associated with reading and writing information to electronic data carriers were resolved. The device demonstrated the ability of a small, hand-held instrument to capture and record relevant patient data without reliance upon auxiliary equipment. Once captured, relevant medical information was easily reviewed and augmented. Accomplishing these objectives effectively removed the primary obstacle encountered in previous attempts to automate the capture of battlefield medical data.

The device further exhibited significant potential for enhancing the user's ability to rapidly and accurately enter and extract critical casualty data. Preloading personal ID information and the automatic time and date stamping of all data entries greatly improves data accuracy and saves valuable time. Simply activating the device provides valuable information to care providers by

automatically recording the time and date of the injury. The device's menu structure lends itself to rapid item identification and selection while enhancing accuracy because only those items related to the user's task are available.

This analysis and evaluation demonstrated the viability of the MEDTAG concept and identified key hardware and software refinements necessary to develop an enhanced prototype. The encouraging pattern of results obtained in these evaluations suggest that the MEDTAG device, because of its unique data entry methodology, may lend itself to a number of applications other than field medical documentation. For example, the device could prove useful as a platform for the administration of computer-aided diagnostics, for personnel tracking and position identification, as well as on remote field sites where portable data collecting capability is required.

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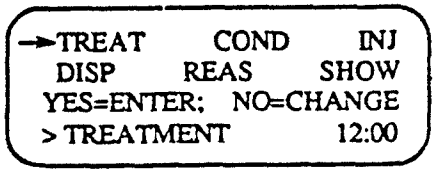
Appendix A

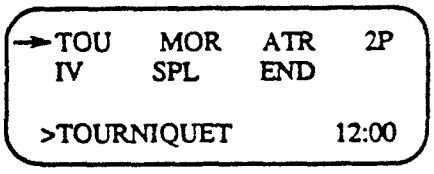
Listing of MEDTAG Menu Data Items

APPENDIX A - Listing of MEDTAG menus/data items

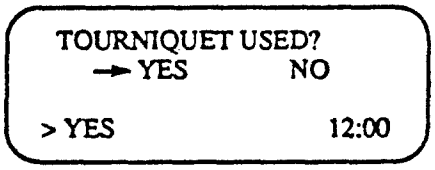
MAIN MENU



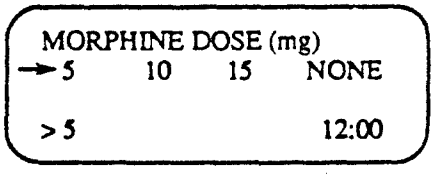
TREATMENT MENU (TREAT)



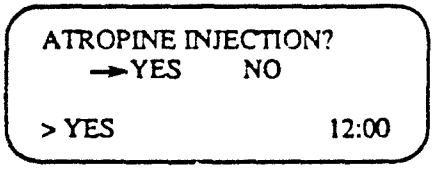
TOURNIQUET MENU (TOU)



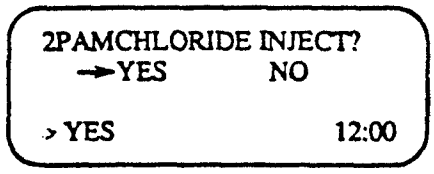
MORPHINE MENU (MOR)



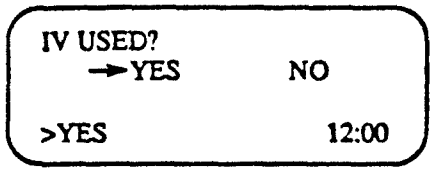
ATROPINE MENU (ATR)



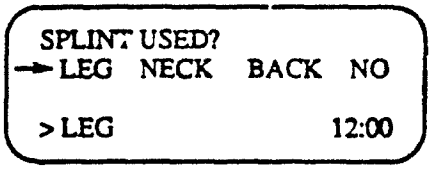
2PAMCHLORIDE MENU (2P)



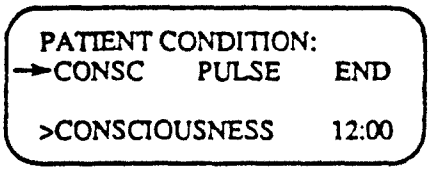
IV MENU (IV)



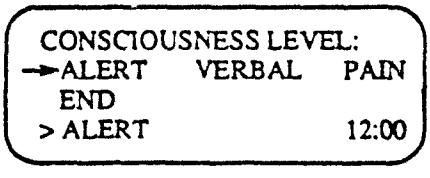
SPLINT MENU (SPL)



CONDITION MENU (COND)

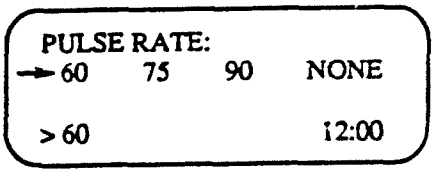


CONSCIOUSNESS LEVEL MENU (CONSC)

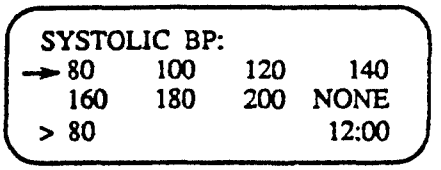


APPENDIX A - Listing of MEDTAG menus/data items

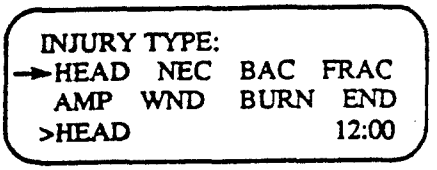
PULSE MENU (PULSE)



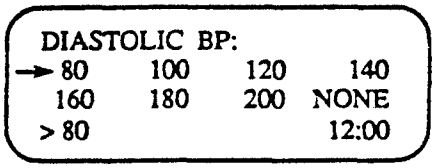
SYSTOLIC BP MENU (SYST)



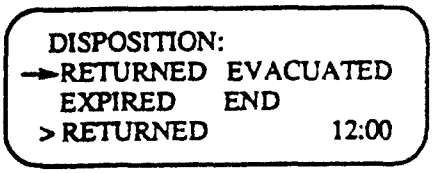
INJURY MENU (INJ)



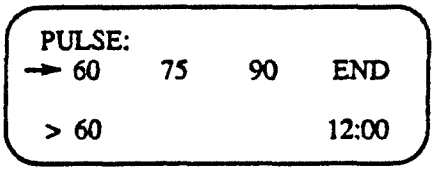
DIASTOLIC BP MENU (DIAST)



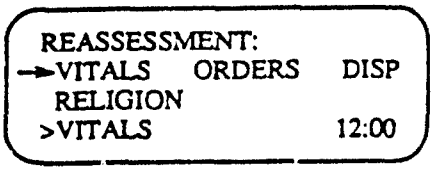
DISPOSITION MENU (DISP)



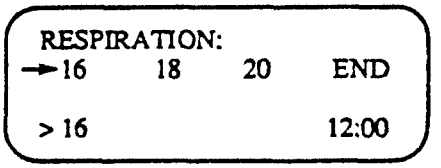
PULSE MENU (PULSE)



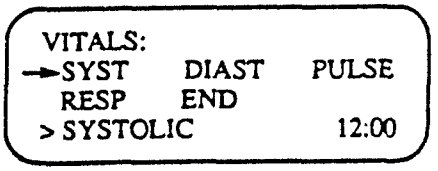
REASSESS MENU (REAS)



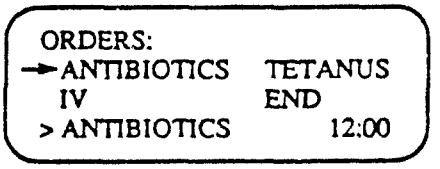
RESPIRATION MENU (RESP)



VITALS MENU (VITALS)

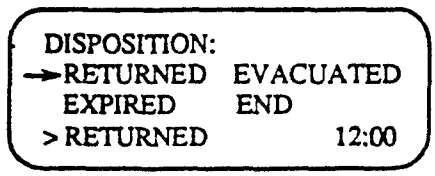


ORDERS MENU (ORDERS)

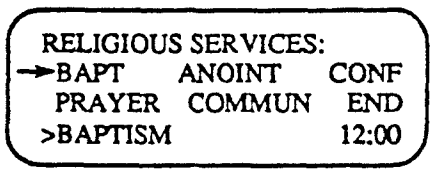


APPENDIX A - Listing of MEDTAG menus/data items

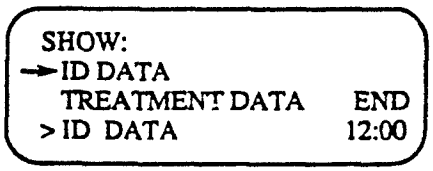
DISPOSITION MENU (DISP)



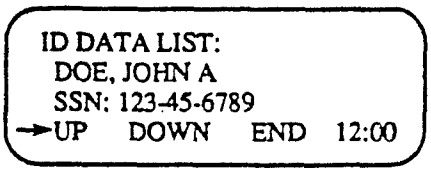
RELIGIOUS SERVICES MENU (RELIGION)



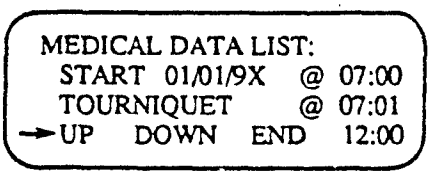
SHOW DATA MENU (SHOW)



SHOW ID DATA MENU (ID DATA)



SHOW MEDICAL DATA MENU (TREATMENT DATA)



Appendix B

Electronic Medical Dog Tag Questionnaire

Appendix B

Electronic Medical Dog Tag Questionnaire

AGE_____ PAY GRADE _____ RATE/NEC _____ DUTYSTA _____ SEX _____

GENERAL EXPERIENCE_____

_____

FMF Y N BATTLE FIELD Y N

DO YOU LIKE THE GENERAL CONCEPT? (1-2-3-4-5-6-7-8-9-10)
BAD----------GOOD

ABOUT THE PROTOTYPE: (PLEASE CIRCLE ONE ONLY)

- Would info taking be speeded up? Y N
- Do you think it'll get in the way? (obtrusive) Y N
- Would it do a better job than the Field Med Card? Y N
- Do you think it may not be used? Y N
- Are the entry buttons in a comfortable/good position? Y N
- Could you see this being used by an untrained person? Y N
- Should the screen size be smaller? Y N
- If backlighted, would it be useful at night? Y N
- Should the device size be smaller? Y N

What problems do you envision in combative & noncombat use?

_____
_____
_____
_____
_____

What problems do you envision in training and getting people to use it?

_____
_____
_____
_____
_____

If you could change one thing what would it be?

_____
_____
_____
_____
_____

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A proof-of-concept model of an electronic battlefield medical data collection device, named MEDTAG, was evaluated to assess the feasibility of automating the capture of casualty medical data. Obstacles encountered in previous attempts to automate the collection of battlefield medical data were addressed by incorporating data capture and display functions and an internal clock into the device. Evaluation of the MEDTAG prototype supported the conclusion that the device could capture combat casualty medical data faster and more accurately than current manual methods. The documentation of Self-Aid and Buddy-Aid were found to be more likely to occur with the MEDTAG device and nighttime documentation was greatly improved. Preloaded personal identification information, automatic time- and date-stamping of all data entries, and the composition of the menu structure which provided only those items related to the user's task, offered substantial potential for saving time and greatly improving data accuracy.

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